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THE BREEDING BIOLOGY OF THE OAHU 'ELEPAIO

SHEILA CONANT

The monotypic genus *Chasiempis* (Muscicapidae) is endemic to the Hawaiian archipelago, and represented by 3 subspecies: *Chasiempis sandwichensis sclateri* on Kauai, *C. s. gayi* on Oahu, and *C. s. sandwichensis* on Hawaii. Commonly called the 'Elepaio, *Chasiempis* is believed to be related to the genus *Monarcha* (Mayr 1943, Amadon 1950), and to be of Melanesian origin by way of Polynesia or Micronesia (Baker 1951). *C. s. gayi* (see frontispiece) was described by Wilson (1891), and is endemic to the island of Oahu.

Despite its wide distribution and relative abundance, this bird has received little attention from field ornithologists. Photographs of the nest and eggs of *C. s. sandwichensis* and of the nest, eggs, and young of *C. s. sclateri* have been published only recently (Berger 1969, 1972).

METHODS AND STUDY AREA

Breeding biology data on the Oahu 'Elepaio were gathered by field observation beginning in November 1965 and ending in May 1968. Brief observations of the Kauai 'Elepaio were made for 3 days in April 1967, 10 days in June 1967, and 7 days in July 1975. From October 1972 to August 1973, and for about 1 week per month from July 1974 to March 1975 I collected data on the Hawaii 'Elepaio while conducting field studies of avian communities on the east flank of Mauna Loa on the island of Hawaii. Although this paper reports primarily the results of my studies of the Oahu population, I have drawn upon observations of the other 2 subspecies to add to my discussion of some topics. Specific information on a particular subspecies will be identified as such.

The main study area consisted of about 70 ha on the northeast side of Manoa Valley on the island of Oahu, and I made occasional trips to other areas. The vegetation of the study area was mesic forest with grassy clearings. Most plants in the area were introduced species.

I recorded song and call-notes with 2 portable tape recorders and 2 types of microphones: a Nagra III with an Electrovoice 655 microphone and a Uher 4000L with a 514 microphone. To determine song patterns in relation to sex and phase of the breeding season I recorded the number of songs given by each member of a pair during the same

hours of the day in each breeding season phase for a total of about 30 h. I also recorded the number of songs and nest material additions by the members of pairs for about 25 h during the first week of construction of several nests. Plumage, behavior, and egg-laying permitted me to sex the birds while data were recorded.

Only 3 birds were banded and color-banded during the study: 1 bird in immature plumage caught in a mist net in November 1966 and 2 nestlings in May 1967. A total of 32 nests were found, 11 of which were collected and measured. Fifty-three eggs in 26 clutches were observed, though none was measured. A small, moveable mirror attached to a length of pipe was used to observe the contents of some inaccessible nests. In nests accessible by using ladders and by climbing trees, I marked 12 eggs as they were laid.

DIET AND FEEDING BEHAVIOR

Although 'Elepaio forage at all canopy levels in the forest, (Perkins 1903, MacCaughy 1919, this study) they were most often seen in the lower story. During 33.3 min of feeding behavior observations of the Hawaii 'Elepaio, birds spent 23.7 min feeding between 0 and 3 m in the canopy, 8.3 min between 3 and 6 m, and 1.3 min above 6 m. MacCaughy (1919) and Richardson and Bowles (1964) mentioned the association of 'Elepaio with various plant species, but Perkins (1903) felt, and I concur, that 'Elepaio are opportunistic feeders, that is, they are most likely to be found where insect densities are highest, regardless of the plant species involved. MacCaughy (1919) and the Hawaii Audubon Society (1967—probably based on MacCaughy 1919) reported nectar feeding, but Munro (1944) and I never saw 'Elepaio eat anything other than animal material, especially insects. After examining stomach contents and observing feeding behavior, Perkins (1903) reported that 'Elepaio fed on a variety of insects as well as arachnids, chilopods, diplopods, and some molluscs.

DISTRIBUTION AND MOVEMENTS

The 'Elepaio is sedentary (Henshaw 1902b), and was reported by MacCaughy (1919) to have the widest altitudinal range of any native forest bird. This is probably still true of all 3 subspecies, although since 1968 I have noticed that densities, though not range, of the Oahu 'Elepaio have decreased. The 'Elepaio can still be found in the backs of most valleys and on ridges on Oahu, but, whereas 8 years ago one would hear or see several pairs on a 5 or 6 km ridge trail, only one, sometimes none, will appear today. The 'Elepaio's adaptability to a wide variety of foods (Perkins 1903), habitats, elevations, and weather conditions (MacCaughy 1919, Richardson and Bowles 1964, Berger 1972:112, 114) is undoubtedly responsible for the success of the species and its wide distribution in comparison to other native forest birds. Henshaw (1902a) predicted that it would persist in substantial numbers after other endemic passerines were rare or extinct.

During the non-breeding season 'Elepaio remained in or near the same area

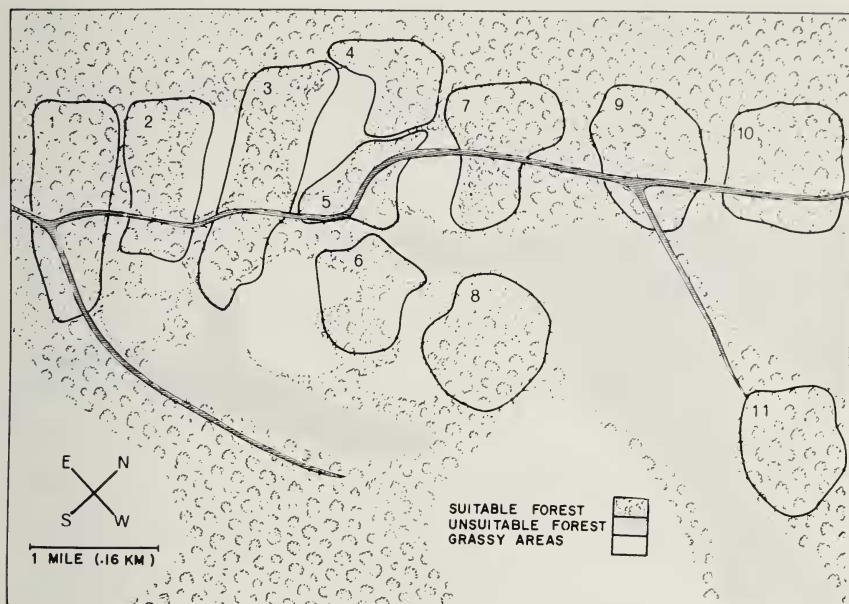


FIG. 1. Territories occupied by breeding pairs of 'Elepaio in Manoa Valley, island of Oahu, Hawaii.

as their breeding or hatching territory the entire year, but I don't know if they always defended territories. From July through December the birds traveled in pairs or family groups, presumably depending on whether or not any young had survived from the previous breeding season. These small flocks disintegrated as males established breeding territories (Fig. 1) by singing in late December or in January. The 2 nestlings banded in May 1967 and their parents exhibited this pattern of behavior. The nestlings hatched and one (the second was not seen after July 1967) remained in or near territory 6 with its parents after the 1967 breeding season. In January 1968 the banded bird established territory 5, pairing with an adult female (pair 5-68—number of pair combines territory number and year of breeding). The presumed parents of this bird (6-67 and 6-68) reestablished their former territory, and bred there. Pair 5-68 renested 3 times. After the destruction of the 4th nest, the banded male did not renest, but remained in territory 5, and his mate was not seen again.

VOCALIZATIONS

According to Henshaw (1902a), the 'Elepaio's name is the Hawaiian transliteration of its primary song, a short, melodious whistle. Perkins (1903)

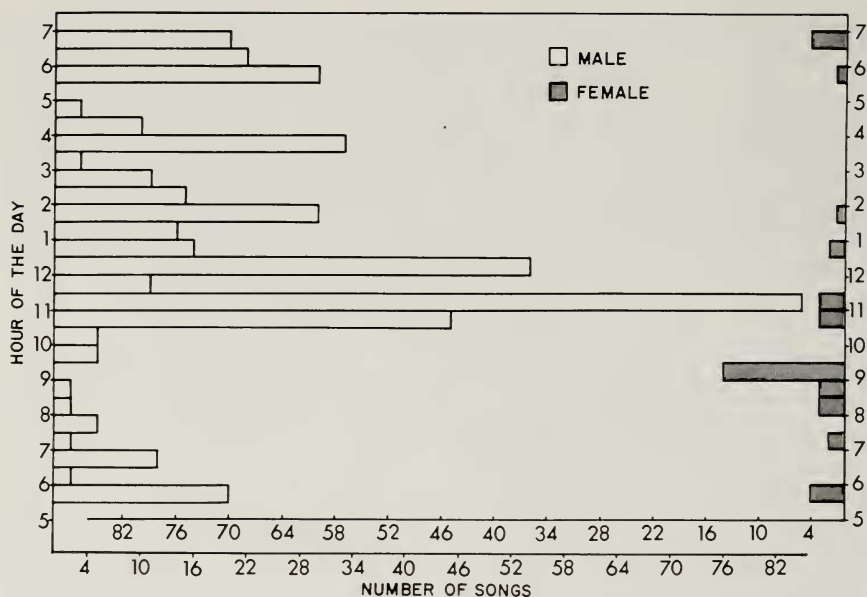


FIG. 2. Number of songs given by both sexes during each hour of the day, during the first week of nest building.

observed that birds often broke into song after intense chatter. I have heard 4 types of vocalizations: chip, chatter, song, and the alarm call. The most common vocalization heard was chatter, which ranged widely in pitch, frequency, and volume. Chatter often preceded songs, which were usually uttered in series of threes. Chatter, unaccompanied by song, was frequent as the birds moved about feeding. Frequent, loud, and excited chatter indicated mild alarm. The alarm call, a short raspy cry, was given by adults and young only when the birds were extremely disturbed, as when the young in the nest were handled or photographed. A high-pitched, soft chatter served as a food-begging call given by nestlings and fledglings, and was similar to the vocalizations of a female indicating readiness for copulation. While feeding and moving about, 'Elepaio often uttered a single, low-pitched chip, apparently as a contact note, maintaining flock or pair contiguity. This chip was also given immediately before birds exchanged places on the nest to incubate or brood, although the male often sang instead. Repeated chips appeared to function as alert notes when a bird was mildly excited or disturbed.

The 'Elepaio was invariably the first bird to sing in the morning, and the last to sing in the evening. During the breeding season I determined territorial boundaries by listening to morning song periods that began before 06:00 and lasted 30 to 45 min, and evening song periods that began at about

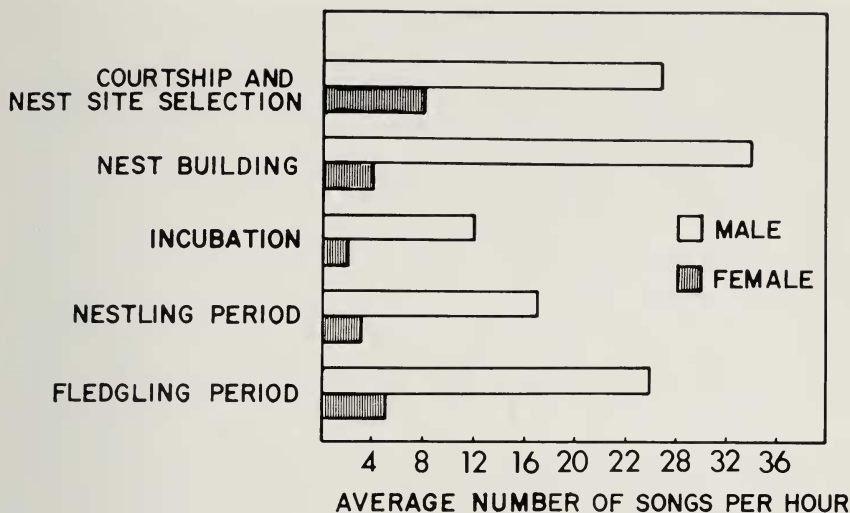


FIG. 3. Average hourly frequencies of songs during the different phases of the breeding cycle.

18:00 and lasted about 20 min. After the morning song period, singing was rather infrequent, except during nest construction. At this time both birds, especially the male, sang frequently throughout the day. Fig. 2 illustrates the average number of songs given by both sexes during a day of nest building. Fig. 3 shows the hourly frequencies of song by both sexes during each phase of the breeding season. During incubation singing was infrequent, except that males often sang once or twice during a nest exchange. The female sometimes sang on the nest in response to a long, excited series of songs and chatter given by the male, and incubating males often responded by singing to the song or chatter of a mate or of an 'Elepaio in an adjacent territory. The frequency of singing by the parents increased after the young hatched and until they became independent.

When the birds were not breeding, song was rare. Although I did not record daily song frequency during the non-breeding season, I noted that morning and evening singing periods decreased in duration and song frequency in June, increasing again in December each year.

'Elepaio responded to tape recordings of chatter with chattering and, occasionally, with singing, especially during the breeding season.

TERRITORY AND NESTING HABITAT

'Elepaio territory should be considered Type A territory (Berger 1961), that is, courtship, copulation, nesting, and feeding occurred within the terri-

tory. Territory was defined by the male, although the female's movements, as she was followed by her singing mate, apparently influenced the location of boundaries. This was especially true in cases where the pair had remained together since the last breeding season. Territorial defense, primarily by song, was shared by both sexes, although the male was slightly more ambitious in defense. Territorial encounters usually resulted in pursuit, the defender chasing the intruder chattering excitedly. I observed such territorial encounters more often in the Hawaii 'Elepaio than in the Oahu 'Elepaio. Red-billed Leiothrix (*Leiothrix lutea*) and Japanese White-eye (*Zosterops japonica*) were silently chased from the area within about 8 m of the nest itself, but other species were usually ignored. I saw birds of these species remove material from 'Elepaio nests twice and once, respectively. Seale (1900) found that 'Elepaio often chased larger birds from feeding grounds, and MacCaughey (1919) reported that 'Elepaio engaged in intraspecific chasing that was both territorial and sexual in nature. 'Elepaio were quite disturbed at human intervention into their territory, particularly near the nest. Several times while nest 3 was being photographed with eggs or young in it, the male attacked the photographer, scratching face and arms with its claws, chattering, giving the alarm call, and fluffing its feathers. The female chattered and fluffed her feathers on these occasions.

Fig. 1 illustrates 11 territories occupied by the breeding pairs studied. It shows habitat type and size of each territory. The size of the territory varied from 1.2 to 2.9 ha, averaging 2.0 ha. C. van Riper (pers. comm.) reported territory size of 17 pairs of Hawaii 'Elepaio to range from 0.65 to 1.46 ha averaging 1.08 ha. This difference between average territory sizes may be related to the fact that his work was done in a sparse, savanna-like, dry forest, in contrast to the dense mesic forest of the present study. The shape of the territory appeared to be influenced by the distribution of clearings and unsuitable nesting habitat. Territories included small clearings ($< 50 \text{ m}^2$), but never encompassed larger clearings, which provided a natural boundary between pairs (Fig. 1: territories 3, 4, and 5). The same reasoning applied to unsuitable nesting habitat, that is, either *Eucalyptus* sp. or paper bark (*Melaleuca leucadendron*) forest in the study area.

Suitable 'Elepaio nesting habitat consisted of dense, mesic forest with thick undercover. The forest was a mixture of several trees: Java plum (*Eugenia cumini*), kukui (*Aleurites moluccana*), fiddlewood (*Citharexylum spinosum*) and guava (*Psidium guajava*). Undercover included a variety of shrubs and grasses: thimbleberry (*Rubus rosaefolius*), ti plant (*Cordyline terminalis*), and palm grass (*Setaria palmifolia*), as well as tree saplings. This description of habitat applies only to the study area—'Elepaio habitat varied throughout Oahu.

COURTSHIP AND COPULATION

Courtship began in January, consisting mainly of singing and chasing. As the male established the territory he attracted a female by singing, or repeated pair formation behavior with his mate of the previous year. In the initial phase of pair formation, 2 birds began associating regularly. Later, patterns of vocal interchange became apparent. This started with chipping, and led to loud, frequent, excited chatter, after which one of the pair sang, the other usually responding by singing. As these singing bouts became more frequent, the birds chased each other in a series of short, swift flights. This chasing was the most characteristic part of courtship, was usually initiated by the male, and was always accompanied by excited chatter and usually by song. Chasing bouts lasted from 20–30 sec to several min, sometimes with short feeding breaks.

The single copulation I observed occurred at 07:20 in the morning about 30–60 min before the female of pair 6-67 laid her second egg in nest 8. As the pair was feeding, the female began low-pitched, excited chatter. After about 30 sec of chattering, to which the male responded in like fashion, the female began to follow him as he hopped from branch to branch. She crouched each time she perched, spreading and quivering her wings and lowering her tail. The male eventually mounted. Mounting and copulation took about 5 sec. After copulation both birds chattered briefly, and the male sang twice. They resumed feeding until I left at 08:00. When the nest, which had contained 1 egg at 08:00, was checked at 08:35, it had 2 eggs in it. The single copulation I observed in the Hawaii 'Elepaio suggested that the behavior patterns of the 2 subspecies are essentially the same.

NEST SITE AND NEST CONSTRUCTION

Nest site selection.—After pairing, the birds began to examine prospective nest sites. The female perched in tree forks or on lateral branches among supporting branches. At each stop she chipped or chattered, and exhibited the nest-molding movement (described below) that both birds used later during nest construction to shape the nest cup. During this time the male usually remained within a few meters of his mate, feeding and answering her vocalizations with similar ones. Occasionally he sang and the female answered with song or chatter. When she began the nest molding movement, singing and chattering became very intense and lasted up to 10 min. After the site had apparently been chosen, the pair repeatedly returned to it and exhibited this same behavior. The ultimate point in this nest site selection pattern was the beginning of nest construction by the female.

Nest construction.—Nests were placed in forks or on lateral branches. The former type of placement was the most common: of the 32 nests observed 27

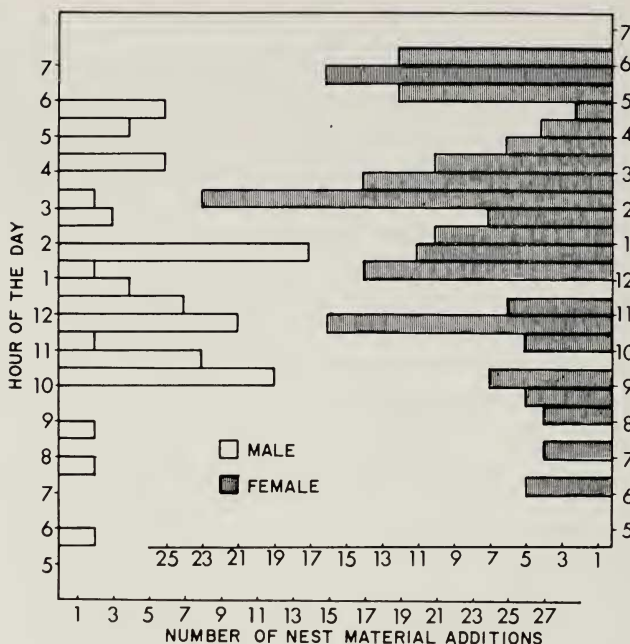


FIG. 4. Number of additions of nest material by both sexes during each hour of the day, during the first week of nest building.

were in forks. Nest height, the distance from the bottom of the nest to the ground directly below the nest, varied considerably. Heights ranged from 2.8 m to 15 m, averaging 7.6 m. Henshaw (1902a) stated that the 'Elepaio habitually nested low. He recorded one nest at less than 0.6 m, but noted that this was unusually low. According to Perkins (1903) nests were placed at heights of 1.8 to 12.2 m.

The nest was built by both sexes, although the female did most of the construction. During the first week of nest building both sexes added material frequently throughout the day. Fig. 4 shows the number of additions of nest material by both sexes during the day. An 'Elepaio often chipped as it worked material into the nest, sometimes singing on the nest or on a perch nearby after the addition. This behavior was especially characteristic of the male, and accounted for the ease with which I often found nests under construction.

'Elepaio used large amounts of spider web and some spider egg cases in the nest. This material strengthened the nest without lending rigidity to it. Web was added with a wiping motion of the head, which served to smooth and shape the outside of the nest. When the nest was nearly complete, the

TABLE 1
SPECIES OF TREES USED AS NEST SITES BY *CHASIEMPIS SANDWICHENSIS GAYI*

| Species of Tree | Number of Nests in Each Species |
|---|------------------------------------|
| <i>Aleurites moluccana</i> (kukui) | 4 |
| <i>Citharexylum spinosum</i> (fiddlewood) | 7 |
| <i>Eugenia cumini</i> (Java plum) | 13 |
| <i>Grevillea robusta</i> (silk oak) | 1 |
| <i>Macadamia ternifolia</i> (macadamia) | 1 |
| <i>Mangifera indica</i> (mango) | 1 |
| <i>Psidium guajava</i> (guava) | 5 |

bird perched in the nest cup, stretched its head out over the edge and used the bill to smooth the entire surface of the nest. The birds shaped the nest cup by sitting in it, erecting the body plumage, and pushing against the surface of the material while shaking the entire body.

Generally the birds did not seem disturbed when I was observing nest building at a distance; however, pair 5-68 deserted nest 27, which was under construction, on the day I spent 2 hours photographing the birds with a strobe light at about 4 m distance.

Most nest construction was complete in a week, although the first egg was usually not laid until about 2 weeks after construction had begun. Small amounts of spider web, lichen, and fine lining material were added during the second week of construction. If the first nest of the season for a pair of 'Elepaio were destroyed or deserted and several days of heavy rains and high winds delayed the construction of a new nest, the new nest was completed and the new clutch laid within 17 days of the date of destruction. In mild weather the time taken to complete the clutch of a renesting was about 11 or 12 days.

The 32 'Elepaio nests I found occurred in 7 species of trees (Table 1). Java plum was the tree most often used as a nest site. All nest trees were introduced species. An analysis of nest 30 revealed that it was composed primarily of the bark of the paper bark tree and the leaves of a grass. The territory from which this nest was taken, territory 5 (Fig. 1), was adjacent to a stand of paper bark trees. The outside of the nest was partly covered with lichen, a liverwort, and the "pulu" (soft, glossy "wool" on the bases of the fronds) of the tree fern (*Cibotium* sp.). The nest was lined with fine rootlets, possibly of a grass, and animal hair. C. van Riper (1977) also found animal hair in Hawaii 'Elepaio nests. I have found leaf skeletons in some nests.

Nest measurements.—Nine of the 11 nests measured had been built in forks, 2 on lateral branches. Average dimensions were: total width, 7.2 cm; total depth, 7.8 cm; cup width 4.6 cm; cup depth, 4.1 cm; wall thickness 1.3 cm. Of previous workers, Bryan (1905) recorded the greatest variations in nest size; he also found more nests placed in upright forks than on lateral branches. Nests reported by Bryan (1905) averaged 7.6 cm in width and height with a cup depth and width of 4.6 cm.

LAYING AND INCUBATION

Eggs and egg laying.—Of the 16 *C. s. gayi* clutches I observed, 15 contained 2 eggs, nest 29 had 3 eggs. Two *C. s. sclateri* clutches I observed had 2 eggs. I have recorded three 2-egg clutches for the Hawaii 'Elepaio and observed 5 pairs of this subspecies feeding 2 young each. Eddinger found eight 2-egg and one 3-egg clutches, and Berger observed 2 pairs feeding 2 young each of the Kauai subspecies (Berger 1972:111). According to Perkins (1903) and MacCaughey (1919) a 2-egg clutch was usual, but Henshaw (1902a) recorded one 3-egg clutch.

The first egg laid in nest 32 was destroyed on the day it was laid, and I broke one of the eggs in nest 14 on the day the second egg was laid. Both pairs of birds began incubating and no more eggs were laid, although the pair at nest 14 deserted (for no obvious reason) 4 days after the second egg was laid. This indicated that 'Elepaio are determinate layers.

The eggs were white with reddish-brown spots concentrated at the larger end (Fig. 5). No eggs were measured in this study, but Newton (1897) reported length to range from 2.1 to 2.2 cm and diameter to be from 1.5 to 1.6 cm. Eddinger measured 2 Kauai 'Elepaio eggs at 2.04×1.52 and 2.05×1.53 cm (Berger 1972:111). Rothschild (1893–1900) obviously erred in reporting that eggs measured 1.25 by 1.11 in. Such egg dimensions would be truly remarkable for a 16.4 cm passerine bird. Unfortunately this mistake was carried over at least once (MacCaughey 1919).

Eggs were laid on consecutive days, 2 to 3 days after the birds had stopped adding material to the nest. I recorded the approximate time of laying of the first egg in 2 clutches and the exact time of laying of the second egg in 6 clutches. All these eggs were laid between 06:30 and 08:30. The first egg in nest 5 was laid before 07:30 on 20 April 1966, and the second egg between 06:38 and 06:45 on 21 April 1966; thus, the interval between layings was close to 24 h. The earliest observed clutch of a season was completed on 18 February 1966, the latest on 9 May 1966. The median date of completion was 23 March for 12 clutches recorded over 3 years.

The clutch of nest 5 was the latest clutch laid in any year. This nest was deserted apparently because the male, which had begun to molt, did not



FIG. 5. The clutch of nest 5.

incubate. After several days of incubating by herself, the female deserted. Both eggs were fertile. The male came regularly to the nest, as if to incubate, remaining the entire time the female was gone, but did not sit on the eggs. Nest desertion by this pair was probably due to the physiological changes manifested by a decrease in reproductive behavior—to be expected as the breeding season drew to a close.

Incubation.—The first egg in nest 16 was laid on 6 April 1967, the second on the following day. The eggs had not hatched by 08:00 21 April 1967, but were hatched by 17:00 23 April 1967. Thus, the incubation period, as defined by Nice (1953), was between 14 and 16 days. Eddinger recorded the incubation period at 3 Kauai 'Elepaio nests as 18 days (Berger 1972:111). More incubation period data are needed to clarify the reasons for this subspecific variation, if, indeed it is real. Incubation began immediately after the second egg was laid, and females spent the night on the nest only after laying the second egg. Occasionally a female sat on the nest for short periods, less than a total of 1 h, on the day the first egg was laid. Males and females incubated in shifts, and the eggs were covered almost constantly. Single attentive periods varied from 2 to 44 min. The average attentive period of males was



FIG. 6. 'Elepaio nestlings at nest 29, approximately 10 days old.

12 min, for females 18 min. For the first 3 days of incubation the attentive periods averaged less than 14 min, but after this became longer. Throughout the incubation period the eggs were incubated 96% of the total time (6 h, 26 min) I observed nests. In most cases, when one bird replaced the other, the eggs were uncovered less than 30 sec. On 3 occasions I saw males of 2 different pairs feed their incubating mates.

CARE OF THE YOUNG

At hatching the nestlings had dark pink skin with a sparse covering of black down on the head and dorsal body surface. The gape was orange, the rictus cream. Fig. 6 is a photograph of the 3 nestlings at nest 28 when they were about 10 days old. When the young were ready to leave the nest their wing, back, and head feathers were dark brown at the base and ochreous at the ends. The underparts were buffy white, and the short tail feathers were dark brown. Fecal sacs of nestlings were white with brownish-black tips. The fledgling's head was brown and underparts whitish. There were black down feathers scattered about the head and body (Fig. 7).



FIG. 7. 'Elepaio fledgling, approximately 28 days old.

Both parents brooded and fed the young. I observed a pair brooding their day-old nestling for 5 h, 5 min. The nestling was brooded 96% of this time, and the average attentive periods were 18 min for the female and 10 min for the male. During this time the nestling was fed 5 times and the parents brought food to the nest an additional 5 times, but did not feed the nestling, apparently because it did not gape. The male fed his mate 4 times when she was brooding. The nestling died when it was 3 days old, but the adults continued to brood, although the attentive periods rapidly became shorter. Feeding attempts continued until the nestling was missing from the nest 2 days after it died. The 2 nestlings in nest 16 hatched on 21 April 1967 and left the nest on 6 May 1967. The nestling period, as defined by Berger (1961), was 16 days.

During a 69 min period, pair 6-68 at nest 16 fed their two 9-day-old young 23 times at intervals of less than 4 min, and removed 4 fecal sacs. At nest 29, the parents fed 3 young, approximately 10 days old, about 10 times per hour per nestling during 6 h of observation. At each feeding the adults waited, and if a fecal sac was ejected they picked it up, flew away immediately, and swallowed it; they removed about 3 fecal sacs per hour. In 2 other

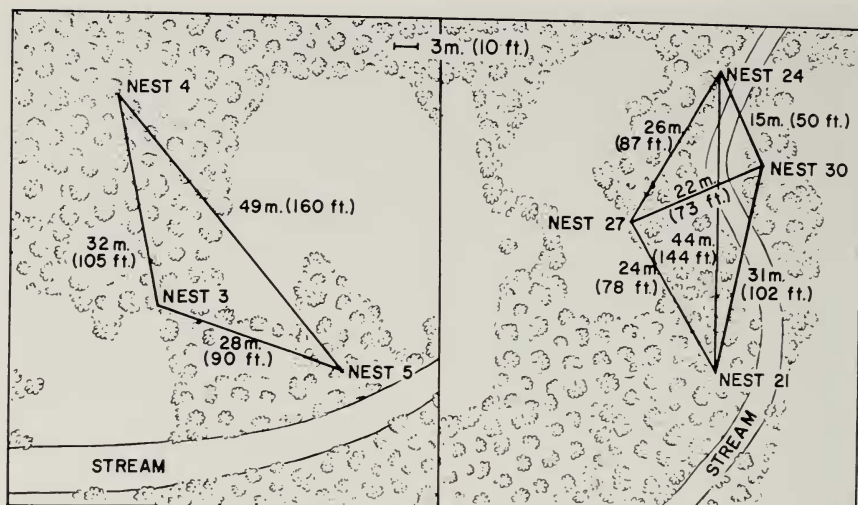


FIG. 8. Diagram of habitat and distance relationships among nestings of pair 1-66 and 5-68. Nests 3, 4, and 5 are those of pair 1-66.

instances I observed 2 adults feed a fledgling 9 times during a 30 min period, and a different pair feed a fledgling once every 7 min for about an hour.

The only previous mention of care of eggs or young was by Rothschild (1893-1900). His collector, Palmer, found a nest on which he collected an adult male that was incubating. Palmer also saw both parents feeding their young.

RENESTING AND NESTING SUCCESS

Most of the pairs I studied renested at least once, first nests having been unsuccessful. In 1966 pair 1-66 renested twice and in 1968 pair 5-68 renested 3 times. Fig. 8 illustrates habitat and distance relationships for the nests of these 2 pairs. Nest dimensions of renestings were similar to those of first nestings, but height, nest habitat, and time taken to build varied.

Because it took a total of about 6 weeks from the beginning of nest construction until the young fledged, and because nesting occurred from February to May, it would have been possible for one pair to raise 2 broods in one season under ideal conditions. Pair 10-68 was feeding fledglings on 4 April 1968, and a pair in territory 10, possibly the same pair, was feeding 2 newly fledged young on 16 May 1968. This suggests that the same pair raised 2 broods in one season.

The total nesting success for 27 nests with 53 eggs was 13%, while hatching success was 29%, and nestling mortality 42%. The figure for hatching success

takes into account both infertility and egg destruction. Clearly the egg stage was the most vulnerable: 34 of 53 eggs observed were destroyed before hatching. Rats, which I observed frequently in the study area both before and after dark, may have preyed upon eggs and young.

The low percentages for hatching and nesting success and nestling mortality may not be typical of the entire species. The Oahu 'Elepaio I studied nested in slender-stemmed trees that bent freely in the wind. The period of high winds and heavy rains, which usually occurred in March, destroyed many nests each year. If the birds had nested in the sturdy native 'ohi'a tree, as they often do in areas where native forest remains intact, fewer nests may have lost eggs or young due to tipping by the wind. In Kokee State Park on Kauai, where 'ohi'a is in abundance, nesting success seemed to be greater, in that nearly every pair of adult 'Elepaio I observed was feeding fledglings in June 1967. Four of the 6 'Elepaio nests I found at Kokee were in 'ohi'a, and Berger (1972) reported that most Kauai 'Elepaio nests observed were in 'ohi'a.

LENGTH OF THE BREEDING SEASON

No author has specified a time duration for the breeding season, although various authors have given all of the months from January through June as breeding months (Bryan and Seale 1901, Bryan 1905, MacCaughy 1919, Richardson and Bowles 1964). There is evidence indicating that each subspecies begins nesting at different times (Berger 1972). In this study, the breeding season of *C. s. gayi* was from mid-January to mid-June. Courtship activities began in mid-January, although males sometimes began territorial singing during the last week of December. Nesting began during the first week of February and continued until May; the last observed young of the season became independent in June.

AGE AT BREEDING

'Elepaio breed in their first year. A male hatched in nest 16 on 21 April 1967 was banded on 1 May 1967. He began building a nest in territory 5 on 7 February 1968, after forming pair 5-68 with an adult female. The female completed her first clutch of the year on 21 February 1968 in nest 21. This pair renested 3 times without success, and the female completed 2 more clutches. Perkins (1893) and Bryan and Seale (1901) believed that breeding of the species in immature plumage was rare. However, Perkins (1903) reported that birds in immature plumage were breeding, and MacCaughy (1919) stated that 'Elepaio paired and nested before assuming the adult plumage.

TAXONOMIC RELATIONSHIPS

Comparisons between aspects of the breeding biology of *Chasiempis* and that of other muscicapids (Stead 1932, Barret 1945, Jack 1949, Vaurie 1953, Oliver 1955, Storr 1958, Kirkman and Jourdain 1966) indicate that its breeding biology is similar to all 4 groups of muscicapids (whistlers, typical flycatchers, robins, and monarchs); however, the data gathered in this study indicate that the 'Elepaio probably belongs to the monarchid group, as Mayr (1943) and Amadon (1950) suggested. Specifically, the roles of the sexes in territoriality, nest building, incubation, and care of the young in the 'Elepaio are more similar to this behavior in monarchs than in whistlers, typical flycatchers, or robins. The appearance, constituents, and placement of 'Elepaio nests are similar to those of monarch nests. In addition, the color of 'Elepaio eggs and the plumage of their young most closely resemble the eggs and young of monarchs.

SUMMARY

The breeding biology of *Chasiempis sandwichensis gayi* was studied from November 1965 to May 1968 in Manoa Valley, island of Oahu, Hawaii. Birds bred monogamously from mid-January to mid-June. The phases of courtship were territory establishment, attraction of females by singing males, and chasing. The territory, which averaged 2.0 ha, was defended against other *C. s. gayi*, *Leiothrix lutea*, and *Zosterops japonica* primarily by males. Nesting habitat in the study area was a dense forest of *Eugenia cumini*, *Aleurites moluccana*, *Citharexylum spinosum*, and *Psidium guajava*; whereas, *Eucalyptus* sp. and *Melaleuca leucadendron* forests were suitable for feeding, but not for nesting. There were 4 types of vocalizations: (1) chipping, given during feeding, or by one bird before it replaced the other on the nest to incubate or brood, or as a mild alerting note; (2) chatter, a prelude to song, a low-intensity alarm note, and, in modified form, a food-begging or copulation-solicitation call; (3) song, given by both sexes; (4) the alarm call, a raspy cry, given by the parents when their young were being disturbed or by the young themselves in the same situation. Singing reached peaks of daily frequency during nest building; it was infrequent during incubation, and increased again from the time the young hatched until they were independent. It decreased after May, and resurged in December.

The nest site, selected by the female, was a tree fork or a lateral branch. Nest building, carried out by both sexes, took about 2 weeks. Nests, placed at an average height of 7.9 m were made of spider web, bark, grass leaves, leaf skeletons, lined with rootlets and animal hair, and covered with lichen and liverwort. Nest width averaged 7.2 cm, depth 7.8 cm, cup width 4.6 cm, and cup depth 4.1 cm. Nest dimensions of renestings were similar to those of first nestings, but height, nest habitat, and time taken to build varied.

Eggs were usually laid in clutches of 2, and were white with reddish-brown spots. The eggs were laid before 08:30 with an interval between layings of about 24 h. They were incubated 96% of the day and all night for at least 14 days. Both sexes incubated, brooded and fed young, and sang on the nest. Nine-day-old young were fed an average of 10 times per hour; the nestling period was 16 days.

Total nesting success was 13%; hatching success was 29%; nestling mortality was

42%. Although high winds and heavy rains were the primary causes of nest failure, predation by rats may have been a factor.

Many aspects of *C. s. gayi*'s breeding biology indicate that it is related to the monarchid group of muscicapids.

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LITERATURE CITED

- AMADON, D. 1950. The Hawaiian honeycreepers (Aves, Drepaniidae). *Bull. Am. Mus. Nat. Hist.* 95:155-262.
- BAKER, R. H. 1951. The avifauna of Micronesia, its origin, evolution, and distribution. *Mus. Nat. Hist., Univ. Kansas Publ.* 3:1-359.
- BARRET, C. 1945. Australian birdlife. Oxford Univ. Press, Melbourne.
- BERGER, A. J. 1961. Bird study. John Wiley and Sons, Inc., N. Y.
- . 1969. The nest, eggs, and young of the Elepaio. *Wilson Bull.* 81:333-335.
- . 1972. Hawaiian birdlife. Univ. Press of Hawaii, Honolulu.
- BRYAN, W. A. 1905. Notes on the birds of the Waianae Mountains. *Occ. Pap. B. P. Bishop Mus.* 2:229-241.
- AND A. SEALE. 1901. Notes on the birds of Kauai. *Occ. Pap. B. P. Bishop Mus.* 1:129-137.
- HAWAII AUDUBON SOCIETY. 1967. Hawaii's birds. Hawaii Audubon Society, Honolulu.
- HENSHAW, H. W. 1902a. Complete list of the birds of the Hawaiian Possessions, with notes on their habits. Hawaiian Gazette Co., Thos. G. Thrum, Publisher, Honolulu.
- . 1902b. The Elepaio of Hawaii. *Auk* 19:225-232.
- JACK, N. 1949. Territory and nesting in the Rufous Whistler. *Emu* 49:26-34.
- KIRKMAN, F. B., AND F. C. R. JOURDAIN. 1966. British birds. Thomas Nelson Ltd., London.
- MACCAUGHEY, V. 1919. The Hawaiian Elepaio. *Auk* 36:22-35.
- MAYR, E. 1943. The zoogeographic position of the Hawaiian Islands. *Condor* 45:45-48.
- MUNRO, G. C. 1944. Birds of Hawaii. Bridgeway Press, Rutland, Vermont.
- NEWTON, A. 1897. On some new and rare birds' eggs. *Proc. Zool. Soc. Lond.* 1897:890-894.
- NICE, M. M. 1953. The question of ten-day incubation periods. *Wilson Bull.* 65:81-93.
- OLIVER, W. R. B. 1955. New Zealand birds. A. H. and A. W. Reed, Wellington.
- PERKINS, R. C. L. 1893. Notes on collecting in Kona, Hawaii. *Ibis* 1893:101-114.
- . 1903. Vertebrata (Aves). Vol. 1, part 4, pp. 368-465 in *Fauna Hawaiiensis* (David Sharp, ed.), The Univ. Press, Cambridge, England.
- RICHARDSON, F. AND J. BOWLES. 1964. A survey of the birds of Kauai, Hawaii. *B. P. Bishop Mus., Bull.* No. 227.
- ROTHSCHILD, W. 1893-1900. The avifauna of Laysan and the neighboring islands. R. H. Porter, London.

- SEALE, A. 1900. Field notes on the birds of Oahu, H. I. Occ. Pap. B. P. Bishop Mus. 1:33-46.
- STEAD, E. F. 1932. The life histories of New Zealand birds. Search Publ. Co., Ltd., London.
- STORR, G. M. 1958. On the classification of the Old World Flycatchers. Emu 58:277-283.
- VAN RIPER, C. 1977. The use of sheep wool in nest construction by Hawaiian birds. Auk 94: (in press).
- VAURIE, C. 1953. A generic review of flycatchers of the tribe Muscicapini. Bull. Am. Mus. Nat. Hist. 100:453-538.
- WILSON, S. B. 1891. On the Muscicapine genus *Chasiempis*, with a description of a new species. Proc. Zool. Soc. Lond. 1891:164-166.
- DEPT. OF GENERAL SCIENCE, UNIV. OF HAWAII, HONOLULU 96822. ACCEPTED 10 MAY 1976.

NEW LIFE MEMBER



Dr. Norman F. Sloan is a new life member of the Wilson Ornithological Society. Dr. Sloan is presently a professor in the Department of Forestry at Michigan Technological University in Houghton. His ornithological interests include avian population dynamics as they relate to biological control of forest insects; he has done considerable work with White Pelicans and also has a research interest in ravens and Peregrines. Dr. Sloan is married and has two children. In addition to belonging to several ornithological societies and other professional organizations, Dr. Sloan has been editor of *Inland Bird Banding News* since 1970.